Age and growth of *Muraena helena* (Muraenidae) from the north coast of Tunisia

by

Balkis SALLAMI* (1) Philippe BÉAREZ (2) & Mohamed BEN SALEM (1)

Abstract. – The age and growth of the moray eel (*Muraena helena)* from the north coast of Tunisia were determined from otolith growth ring studies. A total of 221 specimens were used. Total length (TL) and weight (TW) ranged from 31 to 100 cm and from 45.4 to 2311.9 g, respectively. The transverse section of the otoliths observed under transmitted light proved to be a useful method for ageing *M. helena*. Marginal increment analysis was used to validate the periodicity of increment formation. The age of the specimens ranged from 2 to 10 years in males, and from 2 to 9 years in females. The von Bertalanffy growth parameters were $L_\infty = 198.1$cm, k = 0.063 year $^{-1}$ and $t_0 = -0.797$ years for the combined sexes. Length-weight relationship was determined as follows: $W = 0.0013TL^{3.084}$ (r = 0.948).

Résumé. – Âge et croissance de *Muraena helena* (Muraenidae) des côtes nord de la Tunisie.

L'âge et la croissance de *Muraena helena* ont été étudiés à partir de 221 spécimens collectés sur les côtes nord de la Tunisie, dont 104 femelles et 117 mâles. Leur longueur totale variait de 31 à 100 cm pour des masses totales respectives de 45,4 à 2311,9 g. L'âge a été estimé en comptant les anneaux sur des coupes transversales des otolithes (sagittae). L'analyse de l'allongement marginal a mis en évidence un ralentissement en hiver, correspondant à la formation de l'anneau d'arrêt de croissance. La détermination de l'âge nous a permis de distinguer neuf classes d'âge pour les mâles et huit pour les femelles. L'équation de croissance de Von Bertalanffy, établie pour les sexes combinés, présente les paramètres suivants : $L_\infty = 198{,}1$ cm, $k = 0{,}0632$ an^{-1}, $t_0 = -0{,}797$ an. Pour les sexes regroupés, la croissance en masse de *M. helena* est isométrique par rapport à la taille du poisson (b = 3,084). Chez les mâles la masse et la taille augmentent suivant une allométrie majorante (b = 3,229) alors qu'elle est isométrique pour les femelles (b = 2,894).

© SFI
Received: 18 Aug. 2015
Accepted: 2 Feb. 2016
Editor: G. Duhamel

Key words
Muraenidae
Muraena helena
Mediterranean Sea
North coast of Tunisia
Age
Growth

The family Muraenidae includes 197 species (Eschmeyer and Fong, 2015). In the north-eastern Atlantic Ocean and the Mediterranean Sea, this family is represented by three demersal predator species: *Muraena helena* Linnaeus, 1758, *Gymnothorax unicolor* (Delaroche, 1809) and *Enchelycore anatina* (Lowe, 1838). The latter was first recorded in the eastern Mediterranean by Ben-Tuvia and Golani (1984), and now extends west towards Malta (Deidun *et al*., 2015). The Mediterranean moray eel (*M. helena)* is widely distributed, from the British Isles to Senegal (Bauchot, 1986), including the Canary Islands, Madeira, and the Azores (Randall and Golani, 1995), the two basins of the Mediterranean Sea, eastern and western, and the Adriatic Sea (Fisher *et al*., 1987). It has also been reported off the north coast of Tunisia by several authors (Gruvel, 1926; Bourgeois and Farina, 1961; Ben Mustapha, 1966; Azouz, 1971, 1974; Bradai *et al*., 2004).

Because of its aggressive behaviour and its habit of hiding in cracks and crevices, the capture of *M. helena* remains difficult, and studies about the biology of this species are scarce. Only a few studies have been published about its age and growth (Matić-Skoko *et al*., 2011 for the Adriatic Sea), food preferences (Matić-Skoko *et al*., 2014) or morphological and molecular analyses (Jiménez *et al*., 2007). However, its large distribution and abundance in certain parts of the Mediterranean make it an important species, for which it is important to obtain reliable information on its age and growth, especially for population dynamics studies.

In teleost fish, age estimation is generally based on sclerochronology, *i.e.* the study of growth marks deposited in hard tissues: bones, scales, and otoliths (Panfili *et al*., 2002). Because *M. helena* is almost scaleless, we used otoliths (sagittae) to study the relation between fish size and age, and to assess growth parameters in moray eels captured along the north coast of Tunisia.

MATERIALS AND METHODS

Landings from three places (i.e., Bizerte, Kélibia and El Haouaria) along the northern coast of Tunisia (Fig. 1) have been studied between December 2011 and December 2013. A total of 221 *M. helena* specimens were collected from lon-

---

(1) Laboratoire de recherche – Biodiversité, biotechnologie et changement climatique, Faculté des Sciences de Tunis, Campus universitaire 2090 El Manar II – Tunis, Tunisie. [Mohamed.BenSalem@fst.rnu.tn]
(2) UMR 7209, Département "Écologie et gestion de la biodiversité", Muséum national d'Histoire naturelle, 55 rue Buffon, 75231 Paris CEDEX 05, France. [bearez@mnhn.fr]
* Corresponding author [balkis.sallami@yahoo.fr]

Table I. - Number of *Muraena helena* individuals sampled per month between December 2011 and December 2013 from the north coast of Tunisia (cumulative data).

Month	December	January	February	March	April	May	June	July	August	September	October	November
Number of specimens	23	31	14	28	12	10	23	20	15	10	14	21

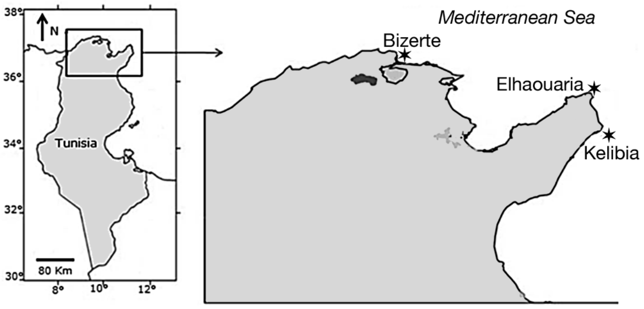

Figure 1. - Map of the study area, indicating the three sampling locations (✶) (North coast of Tunisia, central Mediterranean).

gline and bottom trawlers, caught at depths ranging from 35 to 200 m. A mean of approximately 18 individuals (range 10 to 31) were examined per month (Tab. I). Length and weight ranged from 31 to 100 cm, and 45.4 to 2311.9 g, respectively. For each sample, sagittae were extracted, dried, and stored for future study. The removal of the otoliths was difficult since *M. helena* is characterized by a highly ossified skull. Sex was recorded after a macroscopic and/or a microscopic observation of the gonads. All specimens were sexed and the sex ratio (Sr), percentages of male (%M) and females (%F) were determined according to:

Sr = (number of males/number of females)

%M = percentage of masculinity = (number of males/number of males and females) × 100

%F = percentage of femininity = (number of females/number of males and females) × 100

The sex ratio was analysed using the Chi-square test (χ^2).

The treatment of otoliths was performed at the platform of otolithometry, in the laboratory of ichthyology of the Muséum national d'Histoire naturelle, Paris.

Sections of sagittae were used for age determination. The sagittae were embedded in a polyester resin then sectioned transversely through the nucleus and polished to obtain transverse sections without scratches.

Sections were mounted on glass microscope slides and examined for banding patterns under a binocular microscope (x40) with transmitted light to detect annuli. A drop of rosemary essential oil was placed on the sections to enhance the contrast of rings. All otolith sections were read independently by two researchers.

Marginal increment (MI) analysis was carried out to validate the periodicity of annulus formation in otoliths. MI was calculated as the distance between the outer edge of the last annulus to the edge of the otolith (Hood *et al.*, 1988; O'Sullivan *et al.*, 2003).

For simulating growth in *M. helena*, we used the von Bertalanffy growth function (VBGF), defined by : $Lt = L_\infty (1 - e^{-k(t - t_0)})$, where Lt is the total length at age t; L_∞ (cm) is the asymptotic length; K (year^{-1}) is the rate at which the asymptotic length is approached; t (year) is the age of the fish; and t_0 (year) is the hypothetical age at zero length. The von Bertalanffy growth parameters (L_∞ (cm), k and t_0 (years)) were calculated for the whole sample using the method of Ben Salem and Daget (1991).

For each sample, total length (TL, cm) and total weight (TW, g) were recorded. TL was measured to the nearest 0.1 cm, and TW to the nearest 0.01 g. The relationship between weight and total length is not linear and is best described by a power function of the form $W = a\,TL^b$, where W = weight in grams, a = coefficient factor, TL = total length in centimeters, and b = allometry coefficient. In the most common pattern, the mass varies as the cube of the length (Ricker, 1975; Busacker et *al.,* 1990). An allometric coefficient b value shows an allometric growth when it is larger or smaller than 3, and an isometric growth when it is equal

Table II. - Size (Lt) and weight (W) for the sampled specimens of *Muraena helena*. n: sample size; m: mean; min: minimum value; max: maximum value; SD: standard deviation.

	Male (n = 117)				Female (n = 104)				Combined data (n = 221)			
	m	min	max	SD	m	min	max	SD	m	min	max	SD
Lt (mm)	720.4	330.0	1000.0	128.5	676.5	310.0	925	119.8	699.7	310.0	1000.0	126.1
W (g)	785.6	60.9	2311.9	471.6	599.6	45.4	1780	302.4	698.1	45.4	2311.9	410.8

Table III. - Numerical proportions of males, females and overall sex-ratio of *Muraena helena* from the north coast of Tunisia. n: sample size; %M: percentage of masculinity; %F: percentage of femininity; Sr: sex ratio; χ^2: chi-square test.

Period	n	n male	n female	%F	%M	Sr	χ^2	*P*	Significance
Dec. 2011-Dec. 2013	221	117	104	47.06	52.94	1.125	0.764	0.382	not significant

to 3. In order to confirm whether the b value obtained in the power regressions was significantly different from the isometric value (b = 3) the t-test was used.

RESULTS

The descriptive statistics of total length and weight for the 221 specimens are presented in table II for both sexes and for combined data. Among the 221 specimens of *M. helena* sampled, 104 were females and 117 were males. The male to female ratio was 1.12:1.00, which does not differ statistically from the expected 1:1 (Tab. III). The length frequency distribution of the total sample indicates that the bulk of the catch were between 60 and 80 cm TL (Fig. 2).

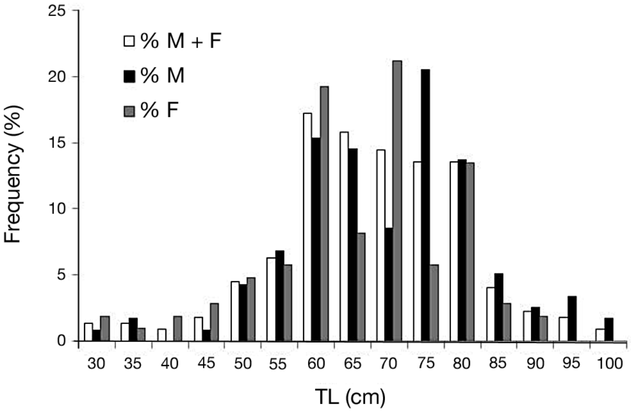

Figure 2. - Length-frequency distribution of females, males and combined sexes for the *Muraena helena* sampled from the north coast of Tunisia.

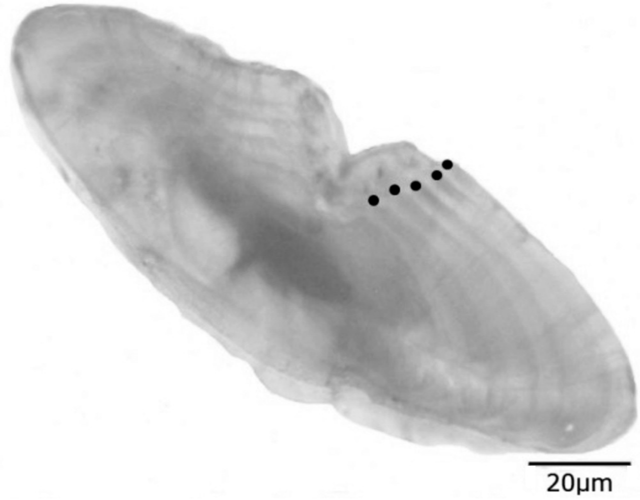

Figure 3. - Transverse section of an otolith (sagitta), observed under a binocular microscope with transmitted light. *Mureana helena* from the north coast of Tunisia (TL = 62.3 cm, W = 442.73 g). Black spots indicate the opaque bands.

Ageing and validation

Under transmitted light, otolith sections showed a dark nucleus surrounded by alternating translucent (annuli) and opaque bands (Fig. 3). The formation of growth increments was validated through marginal increment analysis. The age of each fish was attributed by counting the number of annuli. The analysis of seasonal variations in the mean marginal increment showed that the formation of growth increments clearly followed a seasonal pattern (Fig. 4), and indicates that the mean MI presents a minimum value in winter (0.059), resulting in the appearance of a growth arrest ring. Assuming that one annulus was deposited regularly each year, the counts revealed 9 age classes, ranging between 2 and 10 years. The oldest males and females of *M. helena* were estimated to be 10 and 9 years old, respectively. Age class 7 predominated (26.2% of individuals) in both males and females within the total catch sample. Interestingly, age classes 6 and 7 represented 46.6% of individuals in the total sample, a frequency very close to that found by Matić-Skoko *et al.* (2011) in the Adriatic Sea.

We grouped individuals according to the number of translucent bands they presented, which allowed us to assign

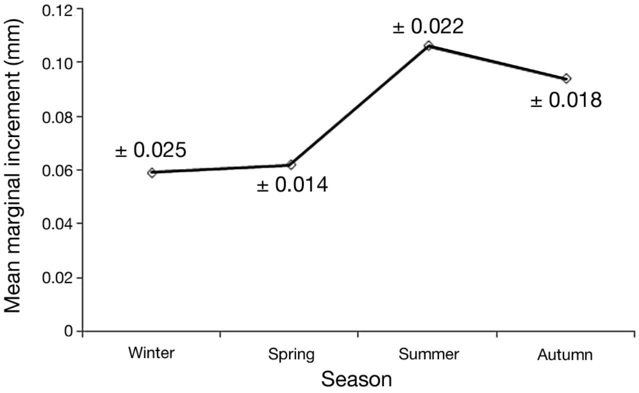

Figure 4. - Seasonal mean marginal increment observed from sagittae sections of ages 2 to 10 *Muraena helena* specimens.

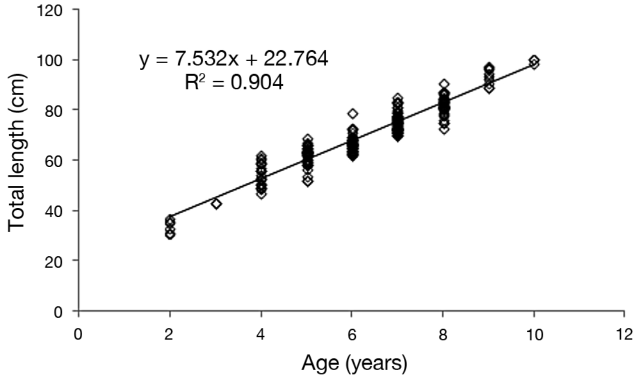

Figure 5. - Relationship between age and total length of *Muraena helena* (n = 221) sampled from north coast of Tunisia.

Table IV. - Age-length key for all specimens of *Muraena helena* from the north coast of Tunisia. m: mean; SD: standard deviation; TL: total length; W: weight.

	Age groups (years)									
Length interval (cm)	2	3	4	5	6	7	8	9	10	Total
30.1-32.5	2									2
32.6-35.0	2									2
35.1-37.5	1	1								2
37.6-40.0										0
40.1-42.5										0
42.6-45.0		2								2
45.1-47.5			1							1
47.6-50.0			3							3
50.1-52.5			4	2						6
52.6-55.0			3	1						4
55.1-57.5			4	1						5
57.6-60.0			3	6						9
60.1-62.5			2	10	3					15
62.6-65.0				15	13					28
65.1-67.5				5	14					19
67.6-70.0				1	10	2				13
70.1-72.5					2	14				16
72.6-75.0					2	15	3			20
75.1-77.5						13	1			14
77.6-80.0					1	6	3			10
80.1-82.5						3	12			15
82.6-85.0						5	12			17
85.1-87.5							4			4
87.6-90.0							1	2		3
90.1-92.5							1	2		3
92.6-95.0								2		2
95.1-97.5								2	1	3
97.6-100.0								1	2	3
Total	5	3	20	41	45	58	37	9	3	221
%	2.26	1.35	9.04	18.55	20.36	26.24	16.74	4.07	1.35	100
m TL (cm)	33.28	41.06	54.12	61.95	66.68	75.40	82.10	93.58	99.00	
SDTL	21.89	35.23	43.48	38.28	33.20	37.95	37.59	34.48	17.32	
m W (g)	64.56	109.20	292.63	430.73	541.01	834.29	967.78	1688.94	2122.95	
SDW	19.62	38.64	88.91	76.17	152.73	171.25	284.80	505.67	5.80	

Table V. - Growth parameters for males and females of *Muraena helena* from the north coast of Tunisia. L_∞: asymptotic length; k: growth coefficient; t_0: theoretical age at zero length.

	L_∞ (cm)	K (yr^{-1})	t_0 (yr)
Males (n = 117)	199.3	0.064	-0.654
Females (n = 104)	194.3	0.059	-1.3

an average length for each age group. Table IV summarizes length and age data for the *M. helena* sampled from the north coast of Tunisia, while figure 5 shows the relationship between TL and age. Despite some overlapping of individuals of different lengths corresponding to the same age, and vice versa, total length and age were well correlated ($R^2 = 0.9$).

The age frequency distribution of *M. helena* (Fig. 6) shows that females were better represented in the age classes 2, 3, 4 and 5, with respective percentages of 2.9, 1.9, 10.6 and 21.1%. In older age groups, especially in the age group 9 and 10, males were more numerous.

Growth model - Length-weight relationship

The VBGF for the entire population sampled had the following parameters: L_∞ = 198.1cm, K = 0.063 yr^{-1} and

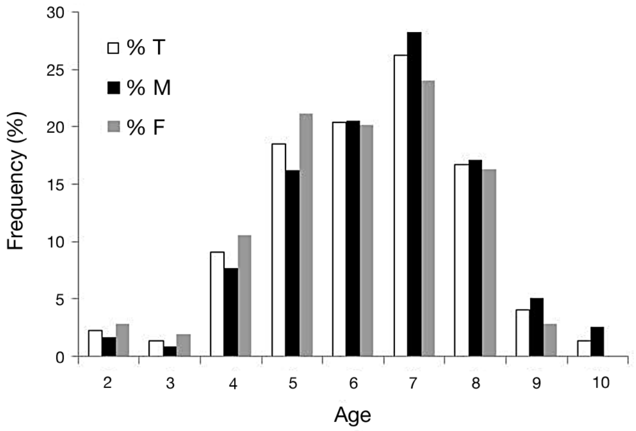

Figure 6. - Age distribution of males (M), females (F) and combined sample (T) of *Muraena helena* from the north coast of Tunisia.

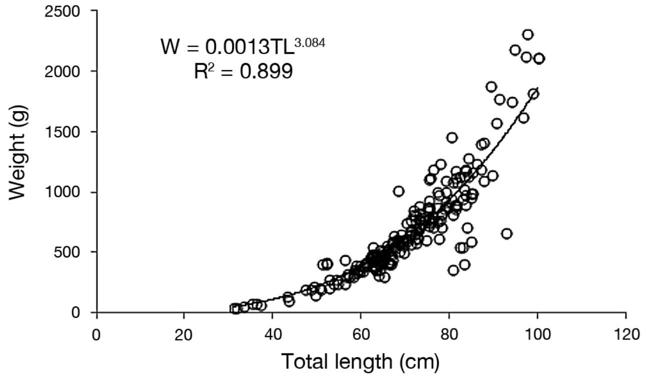

Figure 7. - Length-weight relationship in *Muraena helena* sampled between December 2011 and December 2013 (north coast of Tunisia).

t_0 = -0.797 yr. The estimated parameters for males and females are provided in table V. Growth was similar in both sexes, although females grow at slightly slower rate than males.

The calculated length-weight equation for the whole sample was $W = 0.0013 \times TL^{3.084}$ (Fig. 7). The estimated parameters of the length-weight relationship for the total sample of males and females are shown in table VI. Males showed positive allometric growth with a b value (3.229) significantly different from 3. However, the values of b for females and combined sex were 2.894 and 3.084, respectively, indicating an isometric growth. A correlation coefficient close to 1, for the total sample, male and female, showed that the growth of the fish mass was highly correlated with its size (Tab. VI).

Table VI. - Length-weight relationships ($W = aL^b$) for males, females and total sample of *Muraena helena* from the north coast of Tunisia during December 2011-December 2013 period. R: coefficient of correlation; N: number of specimens.

	Equations	b	R	N	t_{cal} ($t_{0.05}$ = 1.98)	Allometry
Males	$Wt = 0.0007\ TL^{3.229}$	3.229	0.960	117	2.600	Positive allometry
Females	$Wt = 0.0027TL^{2.894}$	2.894	0.931	104	-0.844	Isometry
Total sample	$Wt = 0.0013TL^{3.084}$	3.084	0.948	221	1.187	Isometry

DISCUSSION

Age data of fish populations is highly important, as the majority of biological estimations in fisheries are based on this parameter (Campana, 2001). Otolith reading is a long established method in fisheries for ageing teleosts (e.g., Hederstrom, 1759; Reibish, 1899; Cunningham 1905; Wallace 1907), with interest increasing considerably since the discovery of daily growth marks by Pannella (1971). However, *Muraena helena* is still a poorly studied species, for which only two published data sets are available for its age analysis and growth: one for the Canary Islands (Jiménez *et al.*, 2007), the other for the Adriatic Sea (Matić-Skoko *et al.*, 2011); both of which used the observation of otoliths to determine age. The sagittae of *M. helena* clearly exhibited strong *sclerochronological* information, with cyclical growth marks (zones and annuli) easily identifiable and readable on transverse sections, confirming the results of Matić-Skoko *et al.* (2011).

It is impossible to estimate accurately individual age without precisely identifying the growth marks and the timing of their formation (Panfili and Ximénès, 1994). In an attempt to validate the annual deposition of bands in the otolith (Campana, 2001), marginal increment analysis was carried out. We determined that the opaque zones are completely formed during the summer, while translucent zones are deposited during the autumn/winter period. The mean marginal increment was lowest during the winter; a season characterized by a fall of temperatures and a lack of prey, two factors impacting severely fish growth. Moreover, since *M. helena* rarely leaves its territory, except for short distances in search of prey (Böhlke *et al.*, 1989), it is particularly sensitive to changes in local environmental conditions.

According to our results, the age of *M. helena* from the commercial catch, along the northern coast of Tunisia, varied from two to 10 years. Matić-Skoko *et al.* (2011) indicated that the age of this species varied from two to 12 years in the Adriatic Sea, while Jiménez *et al.* (2007) reported that the age of *M. helena* in the Canary Islands varied from three to 15 years. It is noteworthy that during our survey no specimens under two years old were captured, maybe because of fishing selectivity or because they are not yet sedentarized. The maximum age observed on the north coast of Tunisia was 10 years for a male of 100 cm total length. It is possible that individuals over 10 years exist in Tunisia as the maximal size recorded in this study

Table VII. - Parameters of the length-weight relationship of *Muraena helena* reported by authors in three localities. b: allometric coefficient; R^2: coefficient of determination.

	b	R^2	Allometry	Localities	Authors
Sexes combined	3.314	0.887	Positive	Canary Islands	Jiménez *et al*., 2007
Sexes combined	2.776	0.817	Negative	Southern Adriatic Sea	Matić-Skoko *et al*., 2011
Sexes combined	3.084	0.898	Isometric	North coasts of Tunisia	Present study

Table VIII. - Biogeographic comparison of Von Bertalanffy growth function parameters of *Muraena helena*. n: number of specimens; L_∞: asymptotic length; K: growth coefficient; t_0: theoretical age at zero length.

Sex	Age (year)	n	Age determination	L_{tmin}-L_{tmax} (cm)	L_∞ (cm)	K (an^{-1})	t_0 (an)	Area	Reference
Sexes combined	2-12	193	Otoliths	27.5-121.0	162.7 ± 0.489	0.089 ± 0.003	-0.660 ± 0.219	Southern Adriatic Sea	Matić-Skoko *et al*. (2011)
Sexes combined	3- 15	179	Otoliths	49.0-123.0	170.0	0.078	0.355	Canary Islands	Jiménez *et al*. (2007)
Sexes combined	2-10	221	Otoliths	31.0-100.0	198.1	0.0632	-0.797	North coast of Tunisia	Present study

(100 cm) is substantially lower than in the two above cited studies (121 and 134 cm, respectively). The absence of large specimens might be due to fishing pressure, as moray eels are commonly found on the Tunisian fish markets, or to other reasons (e.g., selectivity of fishing gear, depth).

Mediterranean moray eels from the north coast of Tunisia showed positive allometric growth for males and isometric growth for females. Length-weight relationships can provide useful information about the increase in weight of a population, and this parameter could also be important for comparative studies between populations. Matić-Skoko *et al*. (2011) reported a negative allometric growth (b = 2.776) in the combined sex of *M. helena* collected from the southern Adriatic Sea. Nevertheless, the b value determined by Jiménez *et al*. (2007) for *M. helena* from the Canary Islands was 3.314, indicating positive allometric growth. The length-weight relationship parameters for *M. helena* from various areas are given in table VII.

Comparison of growth parameter estimates of *M. helena* from different geographical areas showed slight discrepancies (Tab. VIII), but global VB models were similar. The biogeographical differences between these regions could possibly explain these growth rate variations, as it has already been observed in the latitudinal populations of several species (e.g., Parrish *et al*., 1985). Along the north coast of Tunisia *M. helena* has a lower growth coefficient (k) and a higher estimated asymptotic length than those reported for the Adriatic Sea or the Canary Islands. *M. helena* is a slow growing and long living Anguilliformes known to attain a large size, up to 2 m, which is in agreement with the asymptotic length of our VB model (198.1 cm).

CONCLUSION

Our study confirms that otoliths are valid and useful ageing structures for moray eels. These new data on age and growth of *M. helena* from Tunisian waters have enhanced our knowledge of this species in the Mediterranean. However, the life cycle of Mediterranean moray eel remains poorly understood, with further biological studies needed to enable better resource management in Mediterranean coastal zones, where it has been exploited since at least the Roman period. In particular, several points require further research: the recruitment and growth of juveniles ($< 2^+$), and the exact mechanism for geographical differences in growth rates of Mediterranean moray eels; since, according to Jiménez *et al*. (2007), *M. helena* shows little genetic divergence among specimens from different localities.

Acknowledgements. – The authors wish to thank Z. Gabsi (MNHN Fish collection), P. Keith and F.J. Meunier (MNHN, UMR 7208) for their effective assistance, support, and for their hospitality during the journey of the first author at the MNHN. Special thanks to C. Lord (MNHN, UMR 7208) for taking the picture of the otolith, and to Jill Cucchi for copy-editing.

REFERENCES

AZOUZ A., 1971. - Étude des biocénoses benthiques et de la faune ichtyologique des fonds chalutable de la Tunisie, région nord et sud-est. Thèse Sci. Nat., 243 p. Univ. Caen, France.

AZOUZ A., 1974. - Les fonds chalutables de la région nord de la Tunisie. 2. Potentialités de la pêche, écologie et répartition bathymétrique des poissons. *Bull. Inst. Natl. Sci. Tech. Océanogr. Pêche Salammbô*, 3: 29-94.

BAUCHOT M.L., 1986. - Muraenidae. *In*: Fishes of the north-Eastern Atlantic and the Mediterranean, Vol. 2 (Whitehead P.J.P., Bauchot M.L., Hureau J.C., Nielson J. & Tortonese E., eds), pp. 537-544. Paris: UNESCO.

BEN MUSTAPHA A., 1966. - Présentation d'une carte de pêche pour les côtes nord de la Tunisie. *Bull. Inst. Océanogr. Pêche Salammbô,* 1(1): 21-38.

BEN SALEM M. & DAGET J., 1991. - Nouvelle méthode d'estimation des paramètres de la croissance chez les poissons. *Cybium,* 15(2): 103-109.

BRADAI M.N., QUIGNARD J.P., BOUAIN A., JARBOUI O., OUANNES-GHORBEL A., BEN ABDALLAH L., ZAOUALI J. & BEN SALEM S., 2004. - Ichtyofaune autochtone et exotique des côtes tunisiennes : recensement et biogéographie. *Cybium,* 28(4): 315-328.

BEN-TUVIA A. & GOLANI D., 1984. - A West African fangtooth moray eel *Enchelycore anatina* from the Mediterranean coast of Israel. *Copeia*, 1984(2): 541-544.

BÖHLKE E.B., MCCOSKER J.E. & BÖHLKE J.E., 1989. - Family Muraenidae. *In*: Fishes of the western North Atlantic, Orders Anguilliformes and Saccopharyngiformes (Böhlke E.B., ed.). *Mem. Sears Found. Mar. Res.*, 1(9): 104-206.

BOURGEOIS F. & FARINA L., 1961. - Rapport au Gouvernement de la Tunisie concernant les essais de chalutage au large des côtes tunisiennes. Rapp. FAO / PEAT, 1410, 31 p.

BUSACKER G.P., ADELMAN I.R. & GOOLISH E.M., 1990. - Growth. *In:* Methods for Fish Biology (Schreck C.B. & Moyle P.B., eds), pp. 363-387. Bethesda: American Fisheries Society.

CAMPANA S.E., 2001. - Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. *J. Fish Biol.*, 59: 197-242.

CUNNINGHAM A., 1905. - Zones of growth in the skeletal structures of Gadidae and Pleuronectidae. *Ann. Rep. Fish. Board Scotland*, 23: 125-140.

DEIDUN A., WATSON D., CASTRIOTA L., MAZZA G. & PASOLLI L., 2015. - First record of the fangtooth moray, *Enchelycore anatina* (Actinopterygii: Anguilliformes: Muraenidae), from Maltese waters, central Mediterranean. *Acta Ichthyol. Piscat.*, 45(3): 315-317.

ESCHMEYER W.N. & FONG J.D., 2015. - Species by Family / Subfamily. (http://researcharchive.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp). Electronic version accessed 31 Mar. 2015.

FISHER W., BAUCHOT M.L. & SCHNEIDER M., 1987. - Fiches FAO d'Identification des Espèces pour les Besoins de la Pêche (révision 1). Méditerranée et Mer Noire. Zone de pêche 37. Vol. I & II, 1530 p. Rome: FAO.

GRUVEL A., 1926. - L'industrie des pêches sur les côtes tunisiennes. *Bull. Stn. Océanogr. Salammbô*, 4: 1- 136.

HEDERSTROM H., 1759. - Rön om fiskars alder. *Handl. Kungl. Vetenskapsakademien* (Stockholm), 20: 222-229. Reprinted in 1959. Observations on the age of fishes. *Ann. Rep. Inst. Freshw. Res., Drottningholm*, 40: 161-164.

HOOD P.B., ABLE K.W. & GRIMES C.B., 1988. - Biology of the conger eel *Conger oceanicus* in the Mid-Atlantic Bight. *Mar. Biol.*, 98: 587-596.

JIMÉNEZ S., SCHÖNHUTH S., LOZANO I.J., GONZALEZ J.A., SEVILLA R.G., DIEZ A. & BAUTISTA J.M., 2007. - Morphological, ecological and molecular analyses separate *Muraena augusti* from *Muraena helena* as a valid species. *Copeia,* 2007(1): 101-113.

MATIĆ-SKOKO S., TUTMAN P., PETRIĆ M., SKARAMUCA D., ĐIKIĆ D., LISIČIĆ D. & SKARAMUCA B., 2011. - Mediterranean moray eel *Muraena helena* (Pisces: Muraenidae): biological indices for life history. *Aquat. Biol.*, 13: 275-284.

MATIĆ-SKOKO S., TUTMAN P., BOJANIĆ VAREZIĆ D., SKARAMUCA D., ĐIKIĆ D., LISIČIĆ D. & SKARAMUCA B., 2014. - Food preferences of the Mediterranean moray eel *Muraena helena* (Pisces: Muraenidae), in the southern Adriatic Sea. *Mar. Biol. Res.*, 10: 807-815.

O'SULLIVAN S., MORIARTY C., FITZGERALD R.D., DAVENPORT J. & MULCAHY M.F., 2003. - Age, growth and reproductive status of the European conger eel *Conger conger* (L.) in Irish coastal waters. *Fish. Res.*, 64(1): 55-69.

PANFILI J. & XIMÉNÈS M.C., 1994. - Évaluation de l'âge et de la croissance de l'anguille européenne (*Anguilla anguilla*) en milieu continental : méthodologie, validation, application en méditerranée et comparaisons en Europe. *Bull. Fr. Pêche Piscic.*, 335: 43-66.

PANFILI J., DE PONTUAL H., TROADEC H. & WRIGHT P.J. (eds), 2002. - Manual of Fish Sclerochronology. 464 p. Brest: Ifremer-IRD.

PANNELLA G., 1971. - Fish otoliths: Daily growth layers and periodical patterns. *Science*, 173: 1124-1127.

PARRISH R.H., MALLICOATE D.L. & MAIS K.F., 1985. - Regional variations in the growth and age composition of northern anchovy, *Engraulis mordax*. *Fish. Bull.*, 83: 483-496.

REIBISH J., 1899. - Uber die Einzahl bei *Pleuronectes platessa* und die Alterbestimmung dieser Form aus den Otolithen. *Helgol. Wiss. Meeresunters.*, 4: 223-248.

RANDALL J.E. & GOLANI D., 1995. - Review of the moray eels (Anguilliformes, Muraenidae) of the Red Sea. *Bull. Mar. Sci.,* 56: 849-880.

RICKER W.E., 1975. - Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board Can.*, 191: 1-382.

WALLACE W., 1907. - Report on the age and growth rate of the plaice in the southern North Sea as determined by the investigation of otoliths, *Mar. Biol. Ass. U.K., Int. Fish. Invest. Rep.*, 2(1): 1-47.